Multiagent Systems Applied to Smart City (NEOM AS A MODEL)

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Abstract
In this paper, we proposed the multi-agent technologies in various fields for smart city projects particularly New Future (NEOM). Indeed, Multi-agent technologies are very effective in solving complex multidisciplinary problems. For conceiving the Multi-agent technologies Model for a smart-city, the proposed paper brings out the wants of the city and the goals to be met. In particular, the conventional six characteristics of a smart city dictate the needs. Based on the proposed multi-agent technological model, we can claim that it can provide the best outcomes in various applications of the smart cities' projects

Keywords:
Multi-agent technologies; smart cities; NEOM;

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1. Introduction

With the recent developments in Artificial Intelligence (AI), Agent and multi-agent-based systems are regaining prominence. Rationality, the most important attribute of an agent, makes it capable to increase rapidly its performance with minimal requirements and energies as well as time and cost [1]. Comparing to simple reflex agent, a model-based agent or goal-based agent [2], [3] [4], the utility-based agent is most proactive and efficient in harsh environments. By providing a measure of performance and success at a given state, it provides an extra component of utility measurement, which makes it special. However, currently, with the extraordinary development of a machine learning techniques, learning an agent is very promising as it is the sort of agent that can learn from previous experiences, or because it has the learning potential [5]. It begins behaving with the fundamental knowledge and then being able to automatically act and adjust through learning. Based on the effective performance, the learning agents are famous and focused by scientific researchers for further improvement and applying to various fields. Its main characteristics consist of flexibility, reactivity, proactiveness and social capability [6]. Multi-agent systems, focused on the interactions of multiple learning agents, have been used in an extensive range of uses, ranging from relatively small personal assistant systems to open complex industrial software systems. Building smart cities with unique opportu-

nities and abilities [7]-[9], require multidisciplinary systems coping with the increasing demand for flexibility, productivity, security, etc. Indeed, the current socio-economic challenges place an increasing pressure on traditional cities to have more effective services and infrastructures, often for a reasonable cost with enough security [10]. Multi-agent systems may offer interesting solutions to the challenges and problems posed by the Smart cities. Indeed, they can offer a high level of success with a high ratio of productivity at a minimum cost and time.

A smart city can be defined as a city that does well in these six characteristics in a forward-looking way: smart governance, a smart economy, smart mobility, smart environment, smart living, and smart human level. In general, the clear vision and mission of the current leadership always introduced these goals and strategies, which revolve around these characteristics [8].

A great and high degree of Information and Communication Technology–ICT has made these smart cities-structures capable of transmitting energy, information flows multidirectional and connecting to various industrials and residential sectors like mobility, water, social, energy, and economy. Consequently, facilities and infrastructure needed for building such smart-cities with the required six characteristics [4], [13], [15], [16], can be further advanced through the emerging rational and learning Artificial Intelligence multi-agents.

Moving in the direction of efficient cities, the leadership of KSA has initiated some new projects for achieving the goals and objectives for their citizens. Neom Business City (Figure 1(a)), New Taif City (see Figure (b)), King Abdullah Economic City (KAEC), King Abdullah City of Atomic and Renewable Energy, and Sudair Industrial City [17]-[20].

(a)

(b)

Fig. 1. The Future model of Neom (a) Taif City (b) Projects

On Wednesday, Saudi Arabia announced that the development of the first NEOM urban area and the $500 billion mega-city planned will begin. Crown Prince Mohammed bin Salman chaired the founding board and has approved the design of the NEOM Bay master plan that will include residence, lifestyles, facilitation for tourism, and “innovation centers” [21]. It is expected that the plan will concentrate on luxury living that will consist of high-end

villas and hotels. The growth of the NEOM Bay area would have a new paradigm of an urban model, allowing it so that it can be a platform for world best mind attraction, to build advanced economic sectors [22].

Fig. 2. The geographical location of Neom -The City of Future Saudi Arabia

Furthermore, on Wednesday 10/01/2020, NEOM revealed that it would implement the groundbreaking solar technologies to generate environmentally sustainable, low-cost energy, enhancing NEOM's reputation as an emerging center for innovation and environmental protection. NEOM strikes out in the development of a solar dome for a sustainable desalination project, as proposed in Figure 3.

Although wishing to turn cities into smart cities, however, they haven't established infrastructure models that make the relation and interaction of different sub-sets to make the smart city real.

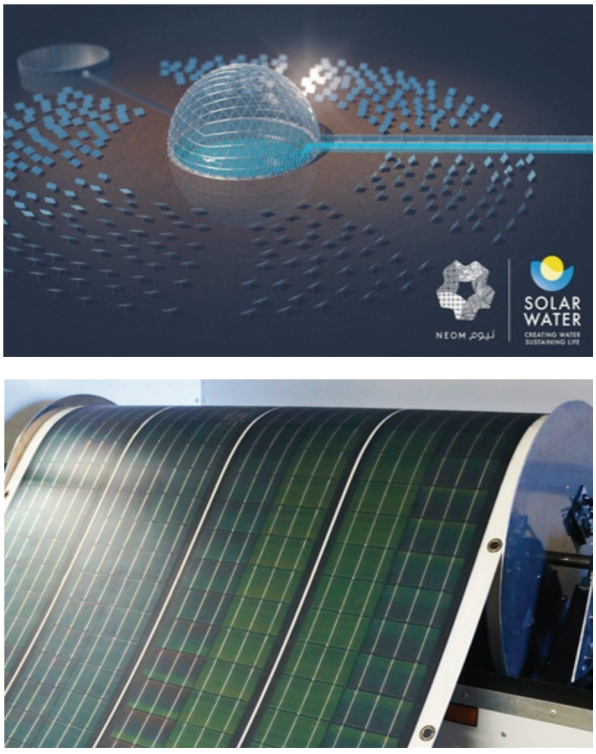

Fig. 3. Neom solar dome technology for water desalination project

The goal of this paper is to explore a smart city model with a multipurpose agent network and the network of things which offers a city with data as a key set-up for defining a concept that can be replicated and exported, as advocated by the European Union [13], [23].

2. Needs and objectives in different sectors of smart cities

It includes developing new high-performance services in different cities so that to become smart. Cities today will need to build innovative and effective services in all sectors.

1.1. Transport and intelligent mobility

Some of the confrontations are to incorpo-

rate multiple types of transport like train, cars, walking, and cycling into a well-organized, sustainable, secure, and with zero carbon footprints integrated networks. Such incorporation allows a reduction in carbon footprints, optimizes the usage of public land and provides a wide variety of accessibility options for city residents to meet all their needs. Moreover, tomorrow's city will have to incorporate new developments in the area of mass transit and electrical activity.

1.2. Environmental management

There are two main zones in which cities need to work: electricity and waste. The challenge that cities will face regarding waste is that of minimizing or eliminating waste manufacture and setting up effective waste recovery and recycling systems (the mechanism by which a waste material or worthless product is updated to a new content or invention of good standard or usefulness). In the field of the electric market, cities will need to reinforce the intervention related to energy effectiveness (low-consumption public lighting innovations) and to create local electric generating systems (waste power generation, solar panels building roofs, etc.).

1.3. Effective urbanizing and smart housing:

Combined with the limited land supply, the high valuation of real estate in city centers make present development multifaceted. In reality, the urban sprawl; costly in terms of land, public services and electricity that has prevailed until now, is not feasible anymore. We must reproduce urban models that simultaneously value required privacy, guarantee enough sunlight, promote "living together" and tolerate any change. Aiming to bring advancement, promote energy efficiency, and also decrease usage, the building would also need to be more intelligent.

1.4. Data and communications technology: the way to efficiently make decisions.

Innovative ICTs (smart meters and sensors, domestic automation, digital media, communication apps, etc.) is going to be in the center of tomorrow's smart city.
The evolution of New ICTs is going to enable effective control of urban areas through the collection and reviewing the main information (renewable electricity generation facilities service, state of public service networks in real-time, road traffic checking, measuring the level of pollution, etc.) via city operating system and modern framework for information management. Such structures promote decision making by local authorities through maintaining the effective use of the knowledge multiplicity. Hence, they make it possible to improve existing services and to bring new infrastructure to the city (organization of charging stations for electrical vehicles, intelligent public lighting, video monitoring, civil warnings, intelligent parking, smart

way of managing waste, etc.) and for the residents (the reduction of water and energy use, waste control, facilitation of urban voyages, protection, etc.).

3. Conceptual Models-based Multi-Agent for applications in Neom smart city

The recent smart city projects requires a high connectivity, automation, flexibility and management between vendors, customers and the network to optimize the data transmission and delivery function [20]. Multi-agent systems technologies are favorite candidates to efficiently implement and manage all these issues. We propose in Figure 4, a conventional conceptual model for the application of Multi-agent systems technologies to Neom smart city.

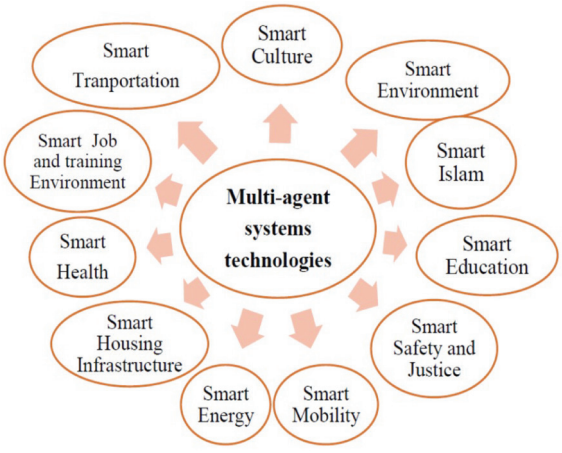

Fig. 4. Conceptual model based multi-agent systems technologies for Neom smart city

Figure 4, shows various applications related to different fields that must be implemented and managed by a common concept. This without forgetting that these applications require systems characterized by specific interaction, collaboration and in some cases, competition and negotiation. multi-agent systems that are known for their high capacity for collaboration, interaction and negotiation, fulfill all these needs.

Figures 5 and 6 propose conceptual models based on multi-agent systems for respectively smart education and smart Islamic applications. In particular, the agents must be of learning types. Indeed, learning agents have a high capacity of adaptation to highly variable environments as the case of smart education and smart Islam.

The Smart City's proposed conceptual models (Figues 4, 5 and 6) are a compilation of views and definitions, which form the basis for discussion of the Smart City's features, uses, attitudes, interfaces, specifications, and standards. The model offers the framework for interoperation and standard analysis, for Neom smart city growth.

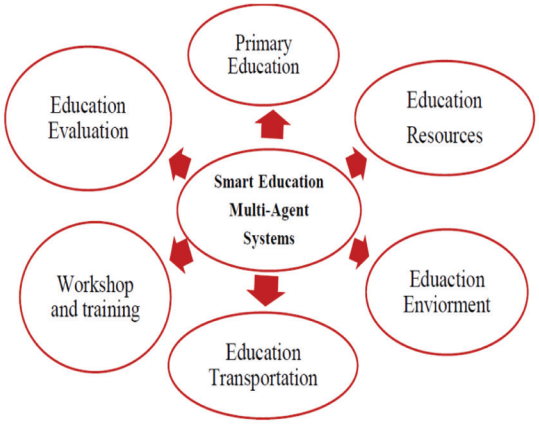

Fig. 5. Conceptual model based multi-agent systems for smart

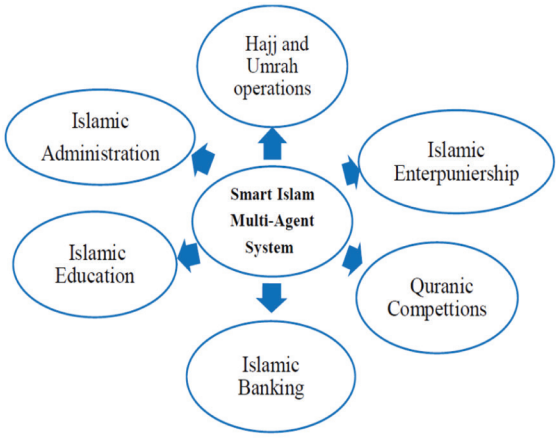

Fig. 6. Conceptual model based multi-agent systems for smart Islam.

4. NEOM smart city model based multi-agent systems

The NEOM is a new future city having many opportunities in the areas of AI-based technologies. The deployment of multi-agent systems technologies in the different smart NEO city applications aims to increase their effectiveness so that this city of the future, which is part of the KSA's vision 2030, will live up to expectations. In the literature, different architectures are proposed for various applications based multi-agent systems [24] [25]. For Neom smart city', the multi-agent system architecture must ensure dynamic and flexible deployment of intelligent agents. Thus, they can handle efficiently the interactions of smart applications related to various fields. To cope with real time complex environment of smart applications, we propose a layered architecture of multi-agent systems. In this architecture, the intelligent agents are deployed on two hierarchical types: coordinator-agent and technical-agents. The technical-agents are concerned by solving the application-specific problems and the coordinator-agents observe the technical-agents and assign scenario to them (see Figure 7.).

A physical layer that contains a network of nodes preinstalled with coordinator-agents supports the layer of coordinator-agents. These nodes are connected by physical links as Wifi, Ethernet and Bluetooth. The coordinator-agents search for other coordinator-agents through physical network and arrange virtual overlay network of coordinator-agents. In addition, the coordinator-agents built a virtual overlay network for technical-agents, so they can communicate and cooperate for the execution of an application scenario. The independence of the overlay network of technical-agents from the physical network' configuration is important for the efficiency of the multi-agent systems.

To maintain the efficiency of the smart city, the networks should not have a considerable relationship with one another; they need to communicate with one another using minimal quantities of shared knowledge with the latest technical instruments.

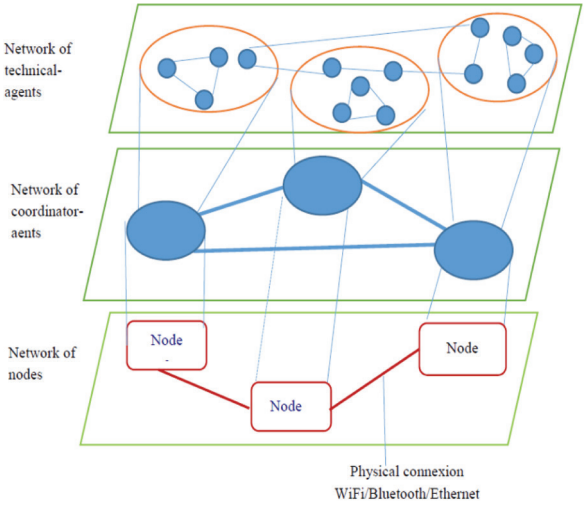

Fig. 7. Proposed multi-agent systems architecture

5. Conclusion

In this paper, we have highlighted the issues and opportunities of using multi-agent in smart cities, particularly in Saudi Arabian smart city projects such as NEOM, Taif City and many other smart projects. Indeed, Multi-Agent Systems are very appropriate for the multidisciplinary smart applications required to build a Smart City with conventionally required characteristics. A conceptual Multi-Agent based model for the future Neom Smart City was proposed. The proposed conceptual models and the multi-agent systems architecture constitute a beginning for future works on the design of a more elaborated model based on Multi-agent systems technologies

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